Gauging Seedlings Growth of Certain Arid Lands Tree Species

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DEDICATION

To my dear parents

To my cherished husband

To my sweetheart daughters

To my beloved sisters and brother

To my friends and colleagues

With all love and respect

Alroda

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In the beginning I thank Allah who provides me with health and successfulness.

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Abstract

This study was carried out to assess some arid lands tree species performance at the nursery stage. Data from this study explain growth properties of these species which is very important when using these species in plantation programmes.

The experiment was conducted in Khartoum forest reserve on the eastern bank of the White Nile abutting the Mugran confluence.

The material for the investigation was six selected arid land tree species *Acacia ehrenbergiana, Acacia nubica, Acacia seyal, Acacia tortilis, Salvadora persica and Ziziphus spina- christi.*

Seeds collected from Gdaref state, Red sea state and Khartoum state were pre-treated for rapid germination and the appropriate tests were done at Soba tree centre.

At the nursery standard operations were implemented. Soil mixture of river silt and sand at 1:1 ratio by volume were packed into 10 x 20 cm polythene bags punctured at the lower ⅔ parts. The filled bags were arranged in seedling beds and flood irrigated in such a way that the soil get wetted by imbibition. This allows smooth wetting of the soil mix and the seeds sown at the top get moisture without disturbance.

Irrigation frequency was every other day in the beginning reduced to twice and once weekly gradually.

Experimental design was complete randomised block design with three replications.Results of nursery tests revealed differences in seedlings growth performance between the different tested species *Acacia tortilis and Ziziphus spina-christi* showed the highest survival percent.

The highest shoot length was attained by Acacia *seyal, Acacia tortilis* and *Acacia ehrenbergiana*. The longest roots were attained by *Acacia tortilis* and *Acacia ehrenbergiana*. This is significant in arid lands since the long seedling roots tap water from deep soil layers. On the basis of height, root length and survival percent, *Acacia tortilis, Acacia seyal, and Acacia ehrenbergiana* are most suitable for arid lands conditions. The other species Acacia nubica, Ziziphus spina christi and Salvadora persica come next.

There for it is recommended that the species selection better to follow the following preference:

1- *Acacia tortilis.*

2- *Acacia seyal.*

3- *Acacia ehrenbergiana*

4- *Acacia nubica.*

5- *Ziziphus spina christi.*

6- *Salvadora persica.*

Acacia nubica being unpalatable for animals and unsuitable as fuel wood, may be used in stabilizing sand dunes and controlling sand movement.

مــوجز البحـــث

أجريت هذه الدراسة لتقييم أداء بعض أشجار الأراضى الجافة في مرحلة المشتل. كما شرحت نتائج هذه الدراسة خصائص النمو لهذه الانواع، الأمر الهام جداً عند استخدام هذه الأنواع في برامج التشجير.

أديرت هذه التجربة في غابة المقرن المحجوزة على الشاطئ الشرقي من النيل الأبيض بمحازات مقرن النيليين.

الطريقة المتبعة للتوضيح كانت اختبار ستة أنواع من أشجار المناطق الجافة هي:-

Acacia ehrenbergiana, Acacia nubica, Acacia seyal, Acacia tortilis, Salvadora persica and Ziziphus spina-christi.

جمعت البذور من ولاية القضارف، ولاية البحر الأحمر وولاية الخرطوم وقد عومل كل نوع من البذور بواسطة المعاملة المناسبة لإسراع النمو كما أجريت لها الاختبارات الضرورية في مركز بحوث البذور بسوبا.

فى المشتل طبقت العمليات الفلاحية القياسية : خليط التربة من الرمل والسلت (١:١) فى أكياس البوليثين(١٠×٢٠) سم بها ثقوب في الثلثي السفليين ثم وضعت هذه الأكياس في مراقد الشتول لتروى رياً فيضياً، بهذه الطريقة تبتل التربة بواسطة الأدمصاص لضمان عدم انجراف الخليط الناعم والبذور التي بذرت فوق التربة. تم الري كل يومين في البداية ثم خفض الي مرتين في الأسبوع ثم مرة كل اسبوع لفترة سبعة أشهر نفذت التجربة بتصميم البلك كامل العشوائية في ثلاث مكررات. أظهرت النتائج بالمشتل اختلافات واضحة في طريقة نمو الشتول للأنواع المختلفة التي تم اختبارها، أظهرت النتائج أن أشجار السيال والسدر أعلى نسبة حياة . كما سجلت أشجار الطلح والسيال والسلم أعلى نسبة لطول المجموعة الخضري.

أما أطول الجذور فقد سجلت بواسطو أشجار السيال والسلم (هذه الخاصية مهمة في الأراضي الجافة لأن جذور الشتول الطويلة تجعلها اكثر قدرة على أمتصاص الرطوبة من الأعماق.

إعتماداً على طول الجذور- ارتفاع النبات ونسبة بقاء الشتول فإن لأشجار السيال والطلح والسلم هي الأكثر مناسبة لظروف الأراضي الجافة، اما الأنواع الأخرى فتأتي في المرتبة الثانية عليه فإن الدراسة توصى باختيار الأنواع وفق الأسبقية الآتية حسب احتمال النجاح في الحقل يكون على النحو التالي:-

١. السيال.

٢. الطلح.

٣. السلم.

٤. اللعوت.

٥. السدر

٦. الأراك

نسبة لعدم استثاغة اللعوت للحيوان وعدم صلاحيتها كوقود يكون من الأفضل استخدام هذه الشجرة لتثييت الكثبان الرملية وإعادة تاهيل الأراضي المتدهورة.

Table of Contents

List of Table

List of Figures

Chapter one

Introduction

The current status of world environment faces serious challenges; the most important one being green cover degradation and its negative impacts on climate change.

According to FAO (2005), Forest plantations amounted to 186.733.000.ha, worldwide giving an annual change of -9,391,000 ha and an annual rate of change of -0.2%. The figures for Africa are 8,036,000 .forest plantations, -5,262,000 ha. Annual change and -0.8% annual rate of change; for the Sudan the corresponding figures are 64,000 ha.plantation,-90.000 ha. Annual change and -1.4% annual rate .The only positive rate is in Europe (+0.1%) meaning that European forests are properly managed and a fforestation / regeneration programmes are efficiently executed. In the Sudan present ratio of forest clearing to planting is 60:1 according to FINNIDA (1990). FNC/FAO (1995) indicated that the annual rate of deforestation ranged from 210,000 to 420,000 ha.

This degradation is caused by many practices like over cultivation and over grazing, fuel wood and forage gathering and of slash and burn, expansion in buildings, wars and civil unrest; all these accelerated by drought and desertification together with increasing population(Doran et al 1983)

This necessitates additional efforts of afforestation and reforestation programmes using suitable tree species that are properly raised in the nursery and efficiently adapted to natural conditions to survive.

This research is under taken to estimate growth of certain arid land tree species at the seedlings stage.

Chapter Two

Literature Review

2.1 Arid Lands:

United Nations Convention On Combating Desertification(1994) defined arid ,semi arid and dry sub- humid zone as areas other than polar and sub -polar regions in which the ratio of annual precipitation to potential evaporation (aridity index) R=P/PET falls within the range of 0.05 to 0.65 viz:

Climatic Zone	Aridity index	%Of world cover
Hyper-arid	$R<0.05$	7.5
Arid	$0.05\leq R<0.20$	12.5
Semi-arid	$0.20\leq R<0.50$	17.5
Dry sub-humid	$0.50\leq R<0.65$	9.9

The P/PET ratio expresses Precipitation (P) as a fraction of the potential evapotranspiration (PET). PET represents the maximum amount of moisture, which could be evaporated at the surface and transpired by available vegetation.*

According to Le Houerou (1977) arid lands are classified as:

*Desert <100 mm rain fall, *Arid land 100-400 mm rainfall, *Semi arid lands 400-600mm.

Globally arid lands constitute about 47% of the Earth's land mass, spread geographically across all continents. They are found in North and South Africa (Appendix 13), West Asia, central Asia, Australia, America and Spain. Africa continent includes the largest area of arid environments (37% of global arid lands) while Australia has the highest proportion-about 75% of its area. Asia embodies 34%, Australia 13%, North America 8% South America 6% and Spain 2% of global arid lands (Appendix 14).

Hopkin and Douglas (1983) quoted by Hussein(2006) reported that In Sudan arid and semi- arid lands (1,217,500) km² represent 48.7% of total country's area; 615,000 km² of this area was classified as arid and 602,500 km² as semi- arid . It was lying between 12° N and 22° N latitude.

Arid lands are characterised by scarce, variable and irregular rainfall, high solar energy and wide diurnal and seasonal temperature variation, strong frequent winds, dust and wind erosion and soil exhaustion. Plant and animals adapted to extreme environmental conditions are unique and endemic. (Hussein 2006).

2.2 Vegetation cover of arid regions of Sudan:

Acacias are the dominant vegetation cover in arid lands of the Sudan. Their distribution is governed primarily by rainfall and soil texture. The principal ecological divisions of tree growth in these lands are desert, *Acacia*- Desert-Scrub, Acacia- Short- Grass Country and Acacia Tall-Grass Country (Smith, 1949).

Deserts of clay soils are treeless on, and north of, the 50 mm isohyet. On coarse open sand sites, *Acacia ehrenbergiana* can be taken as the ultimate arbores cent survivor. Acacia Desert Scrub stretches from 50 mm isohyets wet- ward until the 400mm isohyet. The type of species of *Acacia* desert Scrub is *Acacia tortilis* which occurs with *Acacia seyal* in runnels. The type of Acacia species of Acacia – Short- Grass- Country is *Acacia mellifera* on the clay soils and *Acacia Senegal* on the sands. As for Acacia –Tall-Grass-Country, *Acacia seyal* is dominant over the greatest part of the country. The Blue Nile River and its tributaries, Rahad and

Dinder as well as the river Atbara and Sobat traverse this country. The principle forest features of the Blue Nile River are the chain of annually flooded basins carrying pure forests of *Acacia nilotica*.

According to Smith (1949), when passing from the desert edge wet-wards and considering only occurrences on datum soils, zonation of Acacia species are at once apparent. From the 100mm rainfall isohytes, horizontal belts of *Acacia ehrenbergiana, Acacia nubica,Acacia tortilis*, *Acacia radiana* are apparent, when rainfall reaches 200mm , belts of *Acaia mellifera*, *Acacia fistula*, *Acacia senegal*, *Acacia seyal*, *Acacia drepanolobium*, *Acacia campylacantha*, *Acacia sieberana* and *Acacia albida* follow each other.

According to Adams *et al*. (1978) aridity occurs due to the following factors:

- Separation of Oceans, either by topographical barriers like mountains or by far distance.
- Development of dry stable air masses which resist convective currents and rain formation.
- Lack of storm systems which must lift the air before rain can fall.

Each one of these factors can exist independently or with two other causes.

2.3 Elements considered in establishing aridity pattern:

1. Rainfall: its frequency and amount.
2. Temperature: Range and values.

2.4 Relative humidity of the atmosphere:

Evaporation rates in arid lands are commonly 15- 20 times as much as the annual rainfall, and 30 times the volume of available water. (Adams *et al*., 1978).

In Sudan, the combination of unavailability of moisture, temperature variations, dust storm and the saline and sodic soil conditions constitute the major characteristics of arid and semi- arid lands which are relevant for plant growth. When selecting species for plantations in arid zones of the Sudan the variation in site conditions must be one of the factors that should be considered. Bosshard (1966) mentioned that the soil conditions are considerably different even within relatively small areas such as Khartoum green belt.

2.5 Aridity zones classification according to International Union for Conservation of Nature (IUCN, 2003):

Zone	Vegetation	Land use
Hyper arid	Accidental	Very little
Arid	Bushy woody shrub succulents , some perennial grasses and many annual grasses	Grazing
Semi-arid	Grassland, tropical shrub& Some Savannas, Steppes.	Pastoral grazing, rain fed agriculture.
Dry sub-humid	Grassland, woodlands Savannahs, Steppes	Grazing, ranching, intensive, livestock, rain fed, agriculture irrigated agriculture Forests.

Arid lands are prone to desertification, which is land degradation in arid, semi-arid and sub-humid areas resulting from various factors including climatic variations and adverse human activities like deforestation, over cultivation, over grazing, which are damaging to ecosystem especially in marginal lands .Tribal conflicts, migration and civil unrest aggravate the situation.

Drought enhances desertification process .These drought periods occur as a result of complex climatic mechanisms. Drought years have been more frequent in the last four decades. Population expansion since late 20th century increased the demand for food; hence more land was put under agriculture including marginal areas which were forest and pasture land. In addition, the previous agricultural lands were intensively cultivated .This led to loss of soil fertility and dropping crop yields .Traditional crops showed a drop of 50-80% during years of 1973-1984 as reported by CARE (1985), which also stated that livestock numbers in Sudan have increased six folds since 1957, thus putting extreme pressure on vegetation cover. Moreover deforestation caused by increased utilizations of forest land, negatively affected the natural resources as emphasised by S.C.F (1988).The situation was aggravated more by the civil wars and migration of people and animals.

2.6 Desertification impacts:

Desertification disrupts equilibrium and triggers environmental problems such as sand dune encroachment, loss of land productivity, changing micro climate, wind erosion and increased atmospheric dust and temperature rise causing global climatic change.

The situation is especially serious in Africa where 66% of the agricultural dry lands are already degraded and most of the 800 million people are without adequate food in dry lands (UNEP, 1994).

Desertification activities could be mitigated through integrated development projects in arid, semi-arid and dry sub-humid areas. These projects should aim at prevention and /or reduction of land degradation, rehabilitation of partly degraded land and reclamation of desertified land (UNCED, 1992).

2.7 Desert combating projects in the Sudan:

Afforestation or reforestation projects for mitigation of desertification effects were adopted by the concerned ministries and corporations, agriculture, forestry, range, wildlife, etc. Consequently some projects were implemented all over Northern Sudan e.g., gum rehabilitation programmes , shelterbelts projects ,sand dune afforestation, irrigated plantations ,etc (Hussein, 1998).

All over the world, afforeststion and reforestation are considered as the most important and effective way to conserve, reserve, protect and restoration of already and expected degraded natural resources.

Afforestation means establishing a forest in an area that did not carry a forest within living memory (50 years), while Reforestation is establishing a forest in an area which carried a forest previously (Hussein, 2006).

Artificial regeneration is the common practice for implementing afforestation , reforestation projects , it is achieved by seeds or seedlings .The latter has been adopted in most afforestation works because it is more reliable and has the advantage of uniform growth.

According to Hussein (2006) the need for artificial regeneration in the tropics and sub- tropics is essential to achieve these goals:

1- Create fuel wood plantations near population centres.

2- Grow straight – stemmed trees in savannah woodland areas where such trees are rare.
3- Concentrate merchantable tree species in accessible plots.

To raise seedlings, nurseries should be established in carefully selected sites. These may be permanent, temporary or flying as the situation may dictate. Permanent nurseries provide seedlings for big projects over long periods. Temporary nurseries provide seedlings for short periods.

2.8 General characteristics of tree species to be planted in arid lands:

There are some factors which should be considered in forest management practices in arid lands viz:

Hardiness to survive ecological stresses e.g. drought, soil salinity etc., rapid growth even on poor soils, multiple uses, ability to stabilize and improve environment, minimal management requirement, disease and pest resistance, durability of wood and coppicing ability. In addition nitrogen fixing ability may be considered as one of the important properties of arid land trees, because nitrogen may limit plant productivity of semi- arid soils more severely than water (Felker, 1981).

The primary step to achieve efficient afforestation programmes is adopting the best techniques to raising seedlings or sowing certified seeds. This should ensure production of sturdy plants with good root systems that are essential for optimum survival.

According to Wood *et al.* (1991) unfortunately the season of flowering, fruiting and planting of tropical trees and shrubs are frequently not well known. Therefore reliable field crews should monitor tree phonology, especially flowering and fruiting. These crews should go to the selected tree stands for seed collection when seeds are ripe.

Usually seeds should be obtained as needed and sown soon after receipt. If it is kept more than a few weeks it should be stored according to database on seed handling from international organizations. Generally seeds are dried by air or sun heat and stored in sealed containers in cold (about 4°C) conditions, but they should not be frozen. Seeds of many woody species require special pretreatment before satisfactory germination can be obtained. This may involve physiological changes in the embryo sometimes by chilling or making alteration in the seed-coat to enable water absorption. This change can be induced by soaking in water for 24 hours to immersing in boiling water or sulphuric acid. For some seeds, mechanical scarification of the seed coat may be all that is necessary. Electric scratching by subjecting the seed to electric burner may also be used where it is suitable.

2.9 Principles of propagation:

According to Hudson *et al.* (1968), the propagation of plants is a fundamental occupation of mankind. It started when ancient man grew kinds of plant which fulfilled nutritional needs for himself and his animals in addition to other uses e.g., fibres, medicine, recreation and to cosmetic purpose. It has two types –sexual and asexual. Seed propagation is a sexual one. It involves careful management of germination conditions and facilities and knowledge of the requirements of individual kinds of seeds as follows: (a) seeds must reproduce the particular variety or species which the propagator wishes to grow. This is secured by obtaining seeds from reliable dealers. (b) Seeds must be viable and capable of germination, seeds should germinate rapidly and vigorously to withstand possible adverse conditions in the seed-bed. (c)Any dormancy conditions of the seed which would inhibit germination must be overcome by applying any necessary pre-germination treatment.(d) Any successful propagation depends on proper environment (moisture, temperature, oxygen, fertile soil, light or darkness and control of diseases and insects).

A seed consists of an embryo and its stored food supply, surrounded by protective seed covering. The germination process involves a complex sequence of biochemical, physiological and morphological changes which begins with imbibitions of water by the dry seed which then swells and the seed coats may break. A supply of viable seed is essential in successful propagation from seeds .Viability is represented by the germination percentage, which expresses the number of seedlings which can be produced by a given number of seeds. A reduction in seed viability and vitality may result from incomplete seed development on the plant, injuries during harvest, improper processing and storage (Hudson *et al.*,1968).

2.10 Requirements of tree growth:

Growth of plants is a physiological process largely controlled by levels of light, heat, moisture, nutrients and mechanical stresses which include storms damage, animal predation and human intervention (Reed, 1980 quoted by Ibrahim1988). Requirements for tree growth vary with growth and developmental stages. Seeds require adequate water, oxygen and a suitable temperature. Water availability controls seed germination because no physiological activity takes place before water imbibition. Soil moisture content in excess of field capacity inhibited seed germination of some conifers11 Many seeds will germinate over a wide range of temperature regime. Some of seeds also need constant temperature. Photoperiod and wavelength of light often have pronounced effects on seed germination. For most forest trees, maximum total germination occurs in daily light periods of 8-12 hours.

Oxygen requirement varies, but most seeds can germinate at oxygen tensions below atmospheric concentrations; oxygen is essential for respiration which is an essential phase of germination.

All biological processes are influenced directly or indirectly by heat, nutrient status and water stress. One of the effects of water stress on growth results from stomata closure which reduces photosynthetic rate and therefore productivity. Moisture is the most correlated factor with growth rate than temperature, sometimes it is clearly limiting factor over shading all other factors (Ibrahim, 1988).

Light affects not only the rate of photosynthetic production, but also influences hormonal activity and leaf temperature (Reed, 1980).

Kramer and Kozlowski (1960) reported that growth of a tree begins with germination of seed. The essential event at this stage is resumption of growth by the embryo and its development into an independent seedling. The physiological processes involved in seed germination are absorption of water, largely by imbibition, beginning of cell enlargement and cell division, increase in enzymes and enzymes activity and digestion of stored food, translocation of food to growing regions, increase in respiration, increase in cell division and cell enlargement, and eventually differentiation of cells into the various tissues and organs of seedlings. Seed germination is followed by sequential formation of leaves, nodes and internods from apical meristems. Axillary shoots may originate from apical meristems in leaf axlis. As such shoots may produce additional axillary shoots the young plants are provided with a system of branches. The root apical meristem forms a tap root or primary root. Often branch roots or secondary roots originate at new deeply located apical meristems in tap root. Early germination was reported as decisive significance in determining plant establishment and competitive effectiveness. Under harsh growing conditions of Arizona rapidly germinating seeds only had the most ability to survive.

Once seed germinated most plants enter a state of vigorous vegetative growth during which they cannot be readily induced to a reproductive type of growth; this would be competitively useful in the plant community.

Germination curve usually shows an initial delay in the start of germination, then a rapid increase in the number of seeds that germinate, followed by a decrease in the rate of appearance. During maturation most seeds lose moisture to a level below that required for germination; it can remain in this dry state for long periods of time and can be handled with relative economy, ease and safety. Once sufficient water is absorbed and suitable temperature and aeration conditions prevailed, seeds germinate immediately. Germination percentage can be determined by different tests that include: germinate seeds under optimum environment, seeds testing laboratories, tests of seed viability, purity, seed number per kg and their dormancy. A test usually runs from 10 days to 4 weeks but may continue as long as three months in the case of some slow germination seeds. (Ibrahim 1988).

Germination may fail to take place even under favourable environmental conditions; this germination delaying phenomena, called dormancy, refers to lack of growth in any plant part due either to internally or externally induced factors. The Association of official seed analysis distinguished between “hard seeds” and “dormant seeds”. Hard seeds include those which cannot absorb moisture because of impermeable seed coat. Dormant seeds which are able to absorb moisture but fail to germinate because of restrictive factors in embryo that prevent the initiation of germination. This germination controlling mechanism is important in nature because it contributes to natural survival particularly in desert or cold regions and to dissemination of plants to different areas. One of the internal conditions affecting germination is seed coat and its impermeability to water. Many of plant families contain species whose seeds have hard coats; these include the following families: Leguminsae, Malvaceae, Cannaceae, Geraniaceae and Solanaceae (Hudson *et al*., 1968).

Seeds with hard coat covering may be germinated by any method which artificially breaks or modifies the seed coat. In nature softening of the seed coat comes about through agencies of the environment: mechanical abrasion, alternate freezing and passing through digestive tract of birds or other animals and treatment of seeds by sulphuric acid. Dormant seeds can usually be distinguished from nonviable seeds; the dormant seeds are firm, swollen, free from moulds, or may show erratic sprouting.

2.11 Growing seedlings in the nursery:

Some nurseries propagate seedlings almost entirely, dealing very little in vegetative methods. This is true in the production of trees and shrubs for reforestation, roadside planting, erosion control and similar purposes. Details of the operations vary from nursery to nursery depending upon such factors as the kind of plant, the size of the operation, the purpose for growing and the location of nursery (Wood *et al.,* 1991).

2.12 Time of planting:

Seeds may be planted in the fall or in the spring depending upon their germination requirements and upon management practices of the nursery. (Hudson *et al.* 1968). In cold climates seeds of pines and cupressuses are sown in the autumn 'November' while seeds of quick- growing species are sown in April ' Spring', then singled out after several weeks e.g. Eucalyptus , Csuarina; for hardwood trees, seeds are sown in winter.(Hussein, 2006).

Sowing in nursery requires good viable seeds, well prepared seed beds and the optimum timing. Slow growing species like Conifers and Carobs, are sown early in the autumn and transplanted during winter. Quick growing seeds such as Eucalyptus, *Acacias and Casuarina* are sown at the end of spring. Strong winter rains causes severe damage to seed beds and germinating seeds may be completely damaged. Warm temperatures may cause severe losses by damping off fungi which cause mortality among young seedlings. Some very slow growing species such as Cedar and Juniper may require to be kept in the nursery for more than a year. These may be sown in the spring. Fast growing species do not need more than 8 months in nursery; here early sowing would give too great a development at the top. Too late sowing may coincide with high temperatures which will result in late germination and losses by damping off in temperate zones.

Raising *Acacias* for sand dune fixation may be done by direct sowing in rows in the nursery. The seedlings should not be transplanted in the nursery; for container seedlings, bags are filled with fine soil and pressed well carefully. The bags are watered and when surplus moisture has drained off, seeds are sown and covered with clean sand- the depth of which is more or less equal to the diameter of the seeds; small seeds are sown and covered with sand; large seeds should be pressed lightly into the soil before they are covered – the soil is slightly pressed and watered (Hussein 2006).

Seedlings of many species are grown in seed–beds .The optimum density depends on the species and on the purpose of propagation. Weed control must be done in this stage either by careful seed-bed preparation or by chemical sprays. Cans of 24 cm x 24cmx12cm can accommodate 300- 500 seedlings (100-200 for big seeds); sowing of 3-5 seeds should yield at least 2-3 seedlings. Protection against birds and other pests is done by wooden frames covered with wire netting, scare crows, noise making devices; shiny pieces of tin are useful. Pelletting of seeds by chemical repellents e.g. anthroquinone is a safe guard against pests. Damping off is a seedling disease caused by different fungi which may attack the seed directly or infect the newly germinated plant; affected seedlings will either collapse or remain erect and dry up; a constriction of the stem at the ground line is generally visible; decay occurs in the root and stem; it is controlled by chemicals and thinning the dense germination to give better aeration. Moist and warm weather favours spreading of damping off; therefore seed sowing should not be too early or too late to avoid moisture and temperature (Hussein 2006).

Soil can effectively be sterilized by chemicals such as formol or H_2SO_2 before sowing, then soil should be covered for 10 days after sowing. It is good to thin out surplus seedlings to one in each pot; seedlings will usually be ready for transplanting after 1-4 months.

In Sudan, seedlings are usually raised after the rainy season; some seedlings like *Azadirachta indica* and *Khaya senegalensis* maybe raised in big beds then transferred to the field after one year or more; for *Tectona grandis*, seedlings are pruned before planting in the field; they can also be split into two or four bits and planted separately. This was successful in Western Equatoria.

Nowadays, seedlings are usually produced in polythene bags of various sizes e.g. 10cmx 20cm. In Sudan the lower ⅔ parts of bag is usually pricked for aeration and imbibition; bigger or smaller size may be used according to need then arranged in seed beds built according to standard design. Irrigation in the nursery is through main pipes from which side pipes branch out ending in sprinklers. In small nurseries, plastic pipes with sprinklers at the end are used for irrigation. In Sudan flood irrigation is commonly used, plastic bags are moistened by imbibtion through the prick holes and excess water drains out of the bed by gravity; irrigation is daily, then twice a week, then once a week when seedlings have grown (Hussien 2006).

Usually seedlings are transported outside the shed to open beds before a month of taking to the field for planting; this hardens up the seedlings for tolerating the field conditions. In these hardening beds, irrigation is kept to the minimum but the seedlings should be irrigated immediately prior to the seedlings transporting to the field.

Nurseries' shade can be complete over head or partial shading; also complete sunlight for big seedlings can apply. Important operations in the nursery are weeding and soil loosening which breaks down the soil blocks, reduces weed competition to seedlings and maintains physical soil properties; this facilitates aeration and infiltration thus enhancing seedling growth. Singling follows weeding and it strengthens the root mass especially feeding roots which provide a wider room for a strong shoot development and hence between shoot and root thus helping tolerance of field conditions of cold, frost drought etc. (Hussein 2006).

According to Wood et al (1991) direct sowing is particularly suitable in humid or sub-humid conditions and where seed is cheap and abundant. It becomes progressively more difficult in drier climates. There-fore more attention must be given for raising good seedlings to achieve a successful afforestation programme in arid zones.

In most cases, plants should be raised in polythene sleeves or pots. Seed is either sown directly into pots or germinated first in a seed-bed and later pricked out into pots. If seedlings are raised for field experiments, it is important to keep nursery conditions uniform to get as uniform, planting stock as possible. The field trials should always be designed before the seed is sown in the nursery. Although the nursery conditions are not uniform plants can be arranged in single blocks or replicated to keep it as uniform as possible. Good records must be kept for all the treatments applied in the nursery. Seedlings number required, rejections and replacement in the field should be taken into account. For seedlings raised in nursery the number of seeds must be two to three times the estimated number required. Clear labels must be used to prevent the confusion (Wood *et al.,* 1991). Direct sowing of seeds in containers should be related to germination tests done before; as a rough guide sow two seeds per container if germination is below 80% and transplant surplus seedlings into spare containers; sow one seed per container if germination is over 80% and after about 15 days re-sow any empty containers. If seeds are very small it is better to germinate in seedbeds and later picked out. When seedlings reach 3-5 cm it should be held gently by the cotyledon, not by the stem. For some species transplanting is not easy, there for direct sowing is better e.g. some leguminous species. Seedlings should be watered by very fine water droplets and preferably to be picked out in a cloudy day. Additional care, such as the use of soil mixture from light loam or sandy: Loam 1:1 and the best watering level, to avoid wasting time and loss of valuable seed (Wood *et al.,* 1991).

Whether seedlings are raised in beds or in containers, root pruning is usually required. In beds, root pruning should be done at two-week intervals, alternately pruning side roots and vertical roots. Open containers should be moved weekly to break emerging long roots. Full sunlight and frequent watering are generally the best combination to produce robust planting stock, although shades may be necessary to protect the nursery in areas where hailstorms are prevalent. Where desiccating winds are common, hedges or artificial barriers may be needed to protect the sides of seedbeds. In permanent nurseries, high shed may be desirable, allowing through about 60% of light. There is root inoculation also for some species that require the presence of symbiotic bacteria or fungi for healthy and vigour growth. For most leguminous-nitrogen-fixing species the associated bacteria is Rhizobium type. For Casuarina species, which is also nitrogen-fixing but not leguminous, actinomycete fungi known as Frankia are inoculated. Some trees require more than one micro-organism. These microorganisms are most effective in enhancing tree growth when soil fertility is low or moderate. For this reason, large quantities of inorganic fertilizer should not be applied to nursery soil (Wood *et la.,* 1991).

2.13 Juvenile and adult characteristics:

Physiologically, the juvenile stage can be described as the period when the plant is capable of exponential increases in size, when flowering processes cannot be readily induced, and when the plant develops characteristic morphological forms (Leopold, 1964 quoted by Ibrahim, 1988).

There are some distinctive characteristics such as growth habit and vigour, flowering capacity, leaf shape and structure, ease of rooting of cuttings, internal stem anatomy, leaf retention, thorniness and ability to produce anthocyanin pigments (Kramer and Kozlowski, 1960 quoted by Ibrahim, 1988). When the upper part of the tree reaches the adult phase the lower part often remains juvenile so that both phases may occur on the same plant simultaneously. Many legumes exhibit an abrupt transition from juvenile (simple) to adult (compound) leaves during development. Shoots showing these distinct differences between juvenile and adult phases have been called heteroblastic, as opposite to homoblastic ones in which the transition from the juvenile to the adult phase is gradual.

Failure of fruit or seed crop in adult trees often results from internal blocks at one of the sequential phases of reproductive growth, such as floral induction, flowering, pollination, fertilization, embryo growth, or fruit or seed ripening. Ecology often decides in the seedling stage whether a species is able to colonize a particular site.

Direct seeding is the usual method of establishing *Balanites aegyptiaca* artificially, but due to goat's grazing impact and the effect of water stress natural regeneration and direct seeding of this species may be of less success than seedlings planting specially in stress conditions (Eltahir, 1997). Seeds of *Ziziphus spins-christi* give good germination results when treated by 40% sulphuric acid for 60 minutes (Hussein 1994). Also seeds of *Salvadora persica* show that untreated seeds are better than soaked once in water for different times (Ahmed 1998). Using of fresh clean seeds of species *Azadirachta indica* has higher viability (84%, 73% and14.67%) compared to whole fruits (37.33%, 17.33% and 2.67%) at different maturity stages: green, yellow and brown respectively(Elteraify,1996).

Over the world water supply is a control factor of trees occurrence and production (Larches 1995). In semi-arid and arid tropical regions the success of plantations in many cases depends on effect of water supply for woody plants (Ahmed, 2005).

In Sudan the most commonly adapted plants in dry environments were *Acacias, Salvadora persica,Ziziphus spp ,Eucalypyus spp and Prpsopis chilensis.* Some of these species facing difficulties in natural regeneration, the matter which threaten its sustainability. According to El–amin (1973).*Acacias* are the indigenous species most suitable for arid, semi-arid and savannah zones of Sudan covering about ⅔ of its total area. Commonly these species are used in afforestation , reforestation programmes. Successful afforestation depends on choice of suitable species for each purpose. These should have good nursery performance that would reflect on the subsequent field establishment. Therefore, it is essential to ensure their vigour growth performance at nursery stage.

Trees requirement of water supply during its life is not known or defined clearly yet, but it is more sensitive to moisture stress during the establishment stage compared with their ability to withstand drought once their root systems are fully developed; generally arid land trees have a high root/ shoot ratio (larches,1995).

According to Ahmed (2007) woody plants respond to drought stress by decreasing leaf water potential due presumably to the presence of greater resistance to water flow in their roots.

The initial response of plants to water deficits is the change in turgor pressure in certain cells. After the initial response, there are many secondary effects on plant function. Plant response to mild-to- moderate plant water deficits may be viewed as being either damaging or adaptive. Seed production from most annual plants is reduced by drought during early stages of flowering. The productivity of plants can be substantially reduced by drought during early reproductive stages.

FAO (1988) quoted by Ahmed (2007) reported that there are some indigenous trees tolerant to arid, semi-arid and marginal temporary water logging at 150-900 mm rain like Acacias(*A.albida, A. nilotica, A. saligna, A. Senegal, A. seyal and A.tortilis*). There are other indigenous species like *Balanties aegyptiaca and Ziziphus spina –christi.* Also there are some exotic trees that tolerate drought like *Cassia siamea, Azadirachta indica* and *Eucalyptus spp*. These are adapted to semi-arid and marginal land conditions.

Branney (1990) reported that *Zizphus spina-christi* seedlings were produced using sandy clay loam soil irrigated every two weeks With a mixture of water from River Nile and alkaline water from a well; *Salvadora persica* seedlings growth at nursery was affected by soil, irrigation, temperature and other factors.

Ibrahim (1988) stated that salinity and sodicity adversely affect growth and establishment of seedlings of all taxa. The survival and growth were greater under non-saline and non-sodic conditions. The results are relevant for selection of species at subspecies level. For field trials and as groundwork for studies of the potentiality and salinity and sodicity tolerance of tree species.

Ahmed (1999) stated that under the same prevailing conditions the greatest values of height growth obtained for *Prpsopis chilensis, Acacia nilotica and Acacia seyal* respectively followed by *Acacia mellifera, Acacia tortilis and Acacia senegal;* for survival percentage it was as follows: Acacia mellifera , *Prosopis chilensis, Acacia Senegal, Acacia seyal, Acacia tortilis and Acacia nilotica. Acacia tortilis* was poor both in height growth and survival %, but it developed a deep root which is important in arid land afforestation.

Elobeid (2000) reported thatin a comparative study between two species of *Eucaluptus* : *E. camaldulensis and E. citriodora,* it was concluded that there is a variation between the seedlings of the two species in their response to drought both phisiologically and morphologically. More over it appeared that *E. cmaldulensis* can tolerate drought better than *E. citriodora. E. cmaldulensis* showed a considerable decrease in root growth, but exhibited a significantly greater root: shoot ratio than *E citriodora* in both watering regimes.

Ahmed (2000) recommended that the supplementary irrigation for *Acacia Senegal* seedlings from April to the end of October (the normal growing season or rainy season) is the most suitable because it increases the survival percentage of the seedlings in the first year and the vegetative growth and decreases the period to reach maturity for tapping than that of non- irrigation in the first year. The growth pattern indicates that the tree has a resting period after the normal growing season or during normal dry season which started in winter season and irrigation cannot help in this period. Irrigation of the growing season is more economical.

Abdel Karim (2001) reported that due to weak natural regeneration of *Dalbegia melanoxylon* which is an endangered species, artificial rising of seedlings is desirable and the results showed that germination was best when seeds received no treatment or by soaking the seeds In hot water (60°C) for an hour or in room temperature (27°C) for one day. Seedlings production is best under partial shade. It should be grown in mixture of sand and clay (1:1) by volume to obtain the highest shoot length, shoot fresh weight, leaf fresh weight. Shoot dry weight, root dry weight and leaf dry weight. It may be raised in sand to obtain the highest root length, number of leaves and stem fresh weight. Seedlings should be irrigated daily for two weeks for initial establishment and irrigated every two days thereafter to obtain the highest shoot length, root length, shoot fresh weight, leaf fresh weight and stem fresh weight. Stem cuttings of *Dalbegia melanoxylon* did not root well under applied conditions.

Siam (2001) stated that in a study of seeds of *Acacia Senegal* from four diverse provenances, height and leaflets/pinnae had strongly negative correlation with latitude while height had positive relationship with altitude of seed origin. In both anatomical and morphological traits Dha-bi-ji exhibit more xeromorphic character compared to the other provenances; these traits would be of primary importance in provenance selection for dry land afforestation.

Sapano (2002) reported that in a study of seedlings of *Acacia nilotica* at subspecies level (*adansonii, nilotica, tomentosa*), subsp adansonii had the highest net photosynthesis. and water use efficiency. Also a significant positive correlation was observed between seed size and seedlings growth. Subsp. *adansonii* had the best growth performance and dry weight, and exhibited the highest leaf weight and leaf area which was significantly different from the other subspecies.

In a comparative study between four Acacias (*A. ampliceps, A. stenophylla, A. senegal and A.seyal var. seyal)*, it was recommended that *A seyal var. seyal* be the choice for afforestation and reforestation programmes; for rain fed areas on savannah dark cracking clays, A*cacia senegal* can be used at a small scale second to *Acacia seyal.*The two other exotic Acacias can be used in higher rainfall areas (Rahimatalla 2006).

Ahmed (2007) reported that Ziziphus *spaini- christi* and *Salvadora persica* are suitable species for establishment at arid and semi-arid lands, because they tolerate water shortage up to 5 days irrigation intervals without being adversely affected; the study also showed that *Salvadora persica* from Red Sea is more resistant to water stress than that from North Kordofan and it can be recommended for arid land plantations.

Massaud (2007) reported that natural regeneration of some trees like *Sclerocarya birrea* is not reliable and did not exceed 10% due to damage to seeds. Therefore use seedlings for successful establishment using older and vigour seedlings; protection and soil preparation are necessary operations.

According to Abutaba (2007) for artificial regeneration of *Adansonia digitata*, fresh seed weight showed significant variation between collection dates. Fruit collection in November showed heavier seeds than the other collection periods due to decreasing moisture content of fruit and seeds. Seed planting date had significant effect on germination and root growth. Seeds planted in July showed higher germination percentage and longer seedlings and more leaves than earlier planting (January and April). The effects of seed treatments were less evident for seed planted in July than in January and April. Seed coat scarification using electric burner or concentrated sulphuric acid gave higher germination percentage. From this study it is concluded that seed age and its maturity enhance water and gases exchange leading to overall higher germination percent in July.

2.14 Description of Species under study:

Acacia ehrenbergiana (salam):

It is a shrub 1-5 m high. Crown irregular. Bark of young branches and stem peeling into yellow flakes exposing pinkish bark; bark of old stems grey. Many stems arise from the base. Its habitat is dry sandy plains with rainfall less than 100 mm. It is distributed in Northern desert and semi- desert parts in Northern province, Khartoum , Wadi Siedna , Blue Nile , Medani Khartoum road ,kassala ,Red sea and Suakin. The species is related to Acacia seyal but its habitat is arid sandy and its bark is non –powdery, branching from base with pubescent spines which are always longer then leaves. (El-Amin 1973).It used as fuel wood, timber , forage ,sand creeping control and wind break.(khalifa1996).

***Acaca nubica* (laout):**

It is a Shrub 1-5 m high Crown obconical, branches from base. Bark smooth green- grey or whitish green. Young branches pubescent, green, grey or grey – brownish. Its habitat is semi –desert or dry savannah woodlands on dry hard clays; it also appears on denuded and over cultivated clay fields. It is distributed in central Northern Sudan. In Sudan it is found in Khartoum, kordofan, Darfur and Blue Nile States. Flowering in November-January, fruiting in January-May. It is one of the Acacias which can be use in soil reclamation and sand dune fixation.

***Acacia seyal* (talh)**:

It is a tree 3-17 m tall, crown spreading or irregular. Bark is powdery smooth or sparsely flaking, whitish or greenish yellow or orange-red, sometimes green and red bark occurs in the same tree. Young branch lets are almost glabrous. With numerous reddish glands. It is habitat is dark cracking clay, found often on higher slopes of the rivers and valleys in addition to the hard clay plains of central Sudan. Also in clay depression areas where water is accumulating part of the year. It distributed widely all over the Sudan. Flowering in November-April, fruiting January-May. This tree is used for fodder; it regard as the most important browse and fodder tree in many parts in semi- arid Africa; pods contain up to 19% crude protein, also it use as timber, gum and medicine (El-Amin 1973). It used for good fuel wood, thorny fence. Lopping for forage as leaves, pods, young shoots, and even bark may be eaten. Commercial gum is produced from the tree. Pods and bark contain about 20% tannin and smoke from wood is used as good insect repellent. Many medical uses have been reported. The tree is also used as live hedges, shelterbelts and for sand dune fixation (Vogt 1995).

Acacia tortilis: sub sp raddiana (seyal):

Small shrub to a tree 1-12 m high, crown flat, spreading or irregular; there is one main stem in tree forms and two to many stems in shrubby forms .Bark grey, greyish brown to yellow, smooth or fissured. Young branch lets yellow, brown, and purplish –red. Its habitat is along rivers and seasonal valleys on loamy or gravelly soils on savannah grassland. It is distributed in central, Northern and South –East Sudan. Flowering in December-May, fruiting in February-May. It is regarded as the most important browse and fodder tree in many parts of arid and semi-arid Africa. Pods contain up to 19% crude protein and are used for human and animals consumption. It provides forage from pods through the dry season. The wood is hard and gives a good quality fuel wood and charcoal. It is used for fencing. And local constructions. This species is regarded as potentially important for sand dune fixation. Many medical uses have been recorded including cure of malaria, swollen joints, and skin disorders (Vogt 1995).

Salvadora persica: (Arak)

It belongs to family salvadoraceae and is commonly known as Tooth brush tree or Mustard tree.

It is a small tree \shrub but can reach up to 10 m in good conditions.. The whitish trunk is often twisted and contorted in appearance. The evergreen, slightly fleshy leaves occur in pairs opposite each other on the twigs and have a very distinctive sharp smell (akin to mustard). The fruits are small round berries turning from green to red when mature. This species is most easily identified by its smell, its gnarled trunk (when older) and by its ever green habit even under the driest of conditions. It is distributed in most parts of semi-arid to arid Africa through to Arabia and India.

The most important recognised use for this tree is of the twigs, which are used as toothbrushes where ever it is grown. A kitchen salt can be produced from the wood and leaf ashes. The fruit is edible and is eaten fresh .The leaves and young shoots form a very important browse resource throughout the year for all livestock. Many medical uses have been reported, including treatment for fever, headache, gonorrhoea, bronchitis asthema. It is excellent for sand dune fixation. (Vogt 1995).

Ziziphus spina- Christi: **It belongs to family Rhamnaceae:**

It is a spiny branching shrub or small tree up to 9m high ; ovate lanceolate leaves, thick branching , bark pale grey , thorns in pairs, one straight and one curved ; abundant flowers, greenish yellow. The tree is evergreen in wet sites but drops some or all of the leaves during the dry season on sites where less water is available. It is found usually along rivers in Northern and Central Sudan. Its fruit is edible and the tree is a good fodder for animals .Wood can be used for fire wood and charcoal. Its timber is useful for tool handles, bed stead legs, walking sticks, furniture, bed wood chairs, doors, windows etc. Branches are lopped and used in thorn hedges.It is suitable for afforestation and sand dune stabilization. (Hussein 2006).

Chapter Three

Material and methods

3.1 Materials:

The nursery investigation was conducted in Khartoum forest reserve on the eastern bank of the White Nile abutting the Mugran confluence (15° 34′- 15° 35′ N, 32° 20′- 32° 30′ E).

The species used in the investigation were 6 selected arid land tree species namely: *Acacia ehrenbergiana, Acacia nubica, Acacia seyal, Acacia tortilis, Salvadora persica and Ziziphud aspina- Christi.*

3.2 Methods:

Seeds collected from Gdaref state, Red sea state and Khartoum state were pre-treated for rapid germination and the appropriate tests were done at Soba tree centre.

At the nursery standard, cultural practices were implemented. Asoil mixture of river silt and sand at 1:1 ratio by volume was packed into 10x20 cm polythene bags punctured at the lower ⅔. The filled bags were arranged in seedling beds and flood irrigated in such a way that the soil is wetted by imbibition. This allowed smooth wetting of the soil mix and the seeds sown at the top got moisture without disturbance. Irrigation frequency was every other day at the beginning and then reduced to twice and once a week gradually. Each contained 30 seedlings. Weeding and singling were done after seedlings emergence to a reasonable height. Then root pruning was done when seedlings were 2 months old.

The following growth parameters were recorded at 90,145 and 190 days after planting:

1- Survival (%): estimated by counting the number of surviving seedlings. Expressed as percentage of the initial number of seedlings.

2- Shoot length (cm): determined from a random sample of three plants in each plot. Likewise all the other following parameters

3- Root length. (cm)

4- Diameter at root collar. (mm)

5- Fresh weight of shoot. (mg)

6- Dry weight of shoot. (mg)

7- Root dry weight. (mg)

8- Root fresh weight. (mg)

9- Number of lefelets and pinnae.

10- Root/ shoot ratio.

The experiment was carried out in completely randomised block design with 3 replications. The recorded data were subjected to the analysis of variance, using the SAS programme. The means were separated using the least Significant Difference (LSD) procedure.

Table 1: The layout of the experiment:

I.	*II.*	**III.**
3	6	6
4	2	2
2	4	3
1	1	5
5	5	4
6	3	1

Where: 1- Acacia seyal. 2- Acacia nubica. 3- Acacia ehrenbergiana.

4- Ziziphus spina-christi. 5- Acacia tortilis. 6- Salvadora persica.

Chapter four

Results and Discussion

Results are presented in tables 1-12 and figures 1-.6; ANOVA tables are annexed

4.1. Survival %:

At 90 days, there were highly significant differences among the six evaluated species. (Table 2) shows that the highest mean survival percent (100*%)* was recorded for *Acacia tortilis and Ziziphus spina-christi*, followed b*y Acacia seyal* (92.2%), *Salvadora persica* (92.2%) and *Acacia ehrenbergiana* (88.9%) which were significantly greater than *Acacia nubica* (36.7%).

At 145 days the highest mean survival percent (100%) was recorded for *Ziziphus spina-christi,* followed by *Acacia tortilis* (95.5%), *Acacia seyal* (92.2%), *Acacia* ehr*enbergiana* (88.9%) and *Salvadora persica* (82.2%) which were significantly greater than *Acacia nubica* (22.2%).

At 190 days the highest mean survival percent (97.76%) was recorded for *Acacia tortilis(*97.8%), followed by *Ziziphus spina-christi*(92.2%), *Acacia seyal* (75.5%) and *Acaia echrenbergiana* (72.2%) which were significantly greater than *Salvadora persica* (60%) and *Acacia nubica* (20%). (Figure 1).

From the above results *Acacia tortilis, Zizihpus spina-christi and Acacia seyal* had the highest survival percentages % among the tested species. According to Obied and Mohamed (1971) survival percent for *Acacia seyal* was significantly greater than any other Acacias (Figure 1).

4.2. Shoot length (cm):

At 90 days seedlings age, statistical analysis (Table 3) showed that there were highly significant differences among the evaluated six species. The greatest mean shoot length (32.21cm) was attained by *Acacia Seyal* followed by *Acacia tortilis, Acacia ehrenbergiana, Acacia nubica, Ziziphus spinachristi and Salvadora persica* (13.49cm).

At 145, the greatest shoot length (36cm) was attained by *Acacia seya*l followed by *Acacia ehrenbergiana, Acacia tortilis, Acacia nubica, Ziziphus spina-christi and Salvadora persic*a (14.15cm).

At 190 days seedlings age the greatest shoot length (40.27cm) was recorded for *Acacia ehrenbergiana* followed by *Acacia seyal* .these were significantly greater than *Acacia tortilis, Ziziphus spina-christi, Acacia nubica and Salvadora persica*.

The results show that *Acacia seyal* attained the greatest shoot length .This is akin to a similar research conducted by Rahimatala (2006) at Elrawashda forest reserve where *Acacia seyal* surpassed *Acacia ampliceps* and *Acacia senegal* in root length This character makes Acacia seyal more tolerant of the dry period in the low rainfall savannah zone (Figure 2).

Table2: Mean seedlings survival (%) of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	92.2 a	٩٢,٢ a	75.5 a
Acacia nubica	36.7 b	22.2 b	20 b
Acacia ehrenbergiana	88.9 a	88.9 a	72.2 a
Ziziphus spina-christi	100 a	100 a	92.2 a
Acacia tortilis	100 a	95.5 a	97.8 a
Salvadora persica	92.2 a	82.2 a	61.1 ab
Over all mean	85	80.16	69.8

Figures followed by the same letter in the same column are not significantly different.

Table 3: Mean shoot length (cm) of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	32.21 a	36.00 a	37.72 ab
Acacia nubica	21.83 bc	26.77 b	27.10 c
Acacia ehrenbergiana	26.21 ab	35.61 a	40.27 a
Ziziphus spina-christi	18.55 cd	25.61 b	28.48 cb
Acacia tortilis	27.27 ab	30.05 ab	29.66 cb
Salvadora persica	13.49 d	14.15 c	17.61 d
Over all mean	23.26	28.03	30.14

Figures followed by the same letter in the same column are not significantly different.

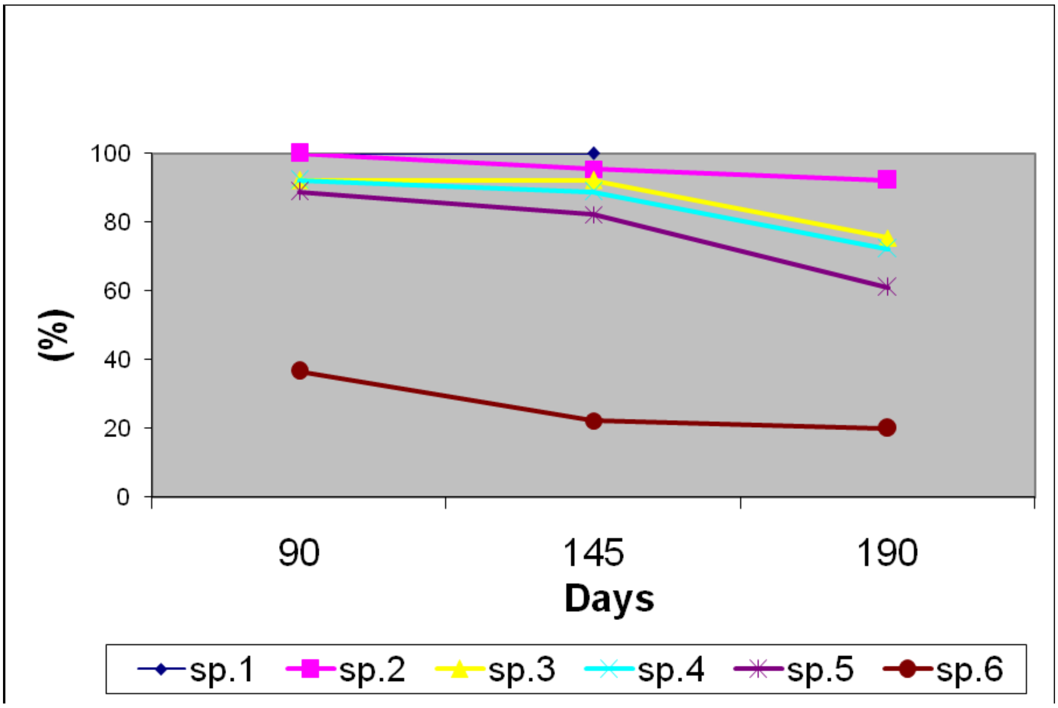

Figure1: Survival percent % of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina,Sp 4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

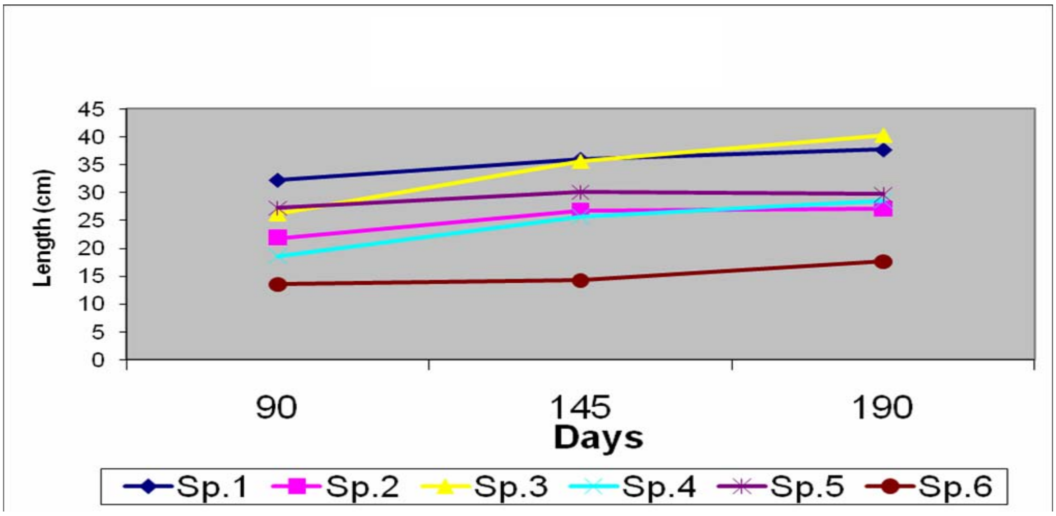

Figure 2: Shoot length (cm) of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina,Sp 4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

4.3. Shoot fresh weight (mg)/ plant:

There were no significant differences between the tested six species at 90 days seedlings age for shoot fresh weight. Similarly no significant differences were detected at 145 and 190 days seedling age.

Thus this parameter does not significantly differ between the species tested. (Table 4).

4.4. Shoot dry weight (mg)/ plant:

There were significant differences among the evaluated six species at 90 seedlings age in shoot dry weight. Table 4 shows that the greatest shoot dry weight (1120 mg) was attained by *Acacia seyal* followed by *Acacia nubica, Acacia ehrenbergiana*, *Acaciaa tortilis*, which were significantly superior to *Ziziphus spina-christi* (300 mg) and *Salvadora persica* (300 mg). (Table 5).

At 145 seedlings age there were significant differences among the evaluated six species. The highest shoot dry weight was obtained for *Acacia ehrenbergiana* (770 mg) which was significantly greater than *Salvadora persica* (300 mg) only.

At 190 days seedling age the highest shoot dry weight/ plant (850 mg) was recorded for *Acacia nubica* followed by *Acacia seyal*, *Acacia ehrenbergiana*, *Acacia tortilis* with no significant differences, but it was significantly greater than Ziziphus spina-christi and Salvadora persica. (Table 5).

Table 4: Mean shoot fresh weight (mg)/ plant of six arid land tree species:

Species \ Days	90	145	190
Acacia seyal	2630 a	1520 a	2120 a
Acacia nubica	2550 a	1580 a	2360 ab
Acacia ehrenbergiana	1710 ab	1600 a	1790 abc
Ziziphus spina-christi	960 b	4940 a	1390 bc
Acacia tortilis	1690 ab	1660 a	1630 abc
Salvadora persica	790 b	1140 a	990 c
Over all mean	1720	1400	1710

Figures followed by the same letter in the same column are not significantly different.

Table 5: Mean shoot dry weight (mg)/ plant of six arid land tree species:

Species \ Days	90	145	190
Acacia seyal	1120 a	660 a	830 ab
Acacia nubica	990 a	630 ab	850 a
Acacia ehrenbergiana	770 ab	770 a	790 ab
Ziziphus spina-christi	300 b	280 ab	510 bc
Acacia tortilis	740 ab	760 a	540 abc
Salvadora persica	300 b	270 b	270 c
Over all mean	700	560	630

Figures followed by the same letter in the same column are not significantly different.

4.5. Root length (cm) / plant:

Statistical analysis showed that there were highly significant differences among the evaluated six species at 90 days seedlings age. (Table 6) showed that the highest root length/plant (32.33cm) was recorded for *Acacia tortilis* followed by *Acacia ehrenbergiana* with no significant differences, but it was significantly greater than all other species *Acacia seyal, Salvadora persica, Acacia nubica and Ziziphus spina-christi.*

At 145 days seedlings age the highest root length/plant (34.32cm) was recorded for *Acacia ehrenbergiana* which was followed by *Acacia tortilis*, *Salvadora persica, Acacia seyal and Acacia nubica* with no significant differences between them, but it was significantly greater than *Ziziphus spina-christ*i (23.10 cm).

At 190 days analysis of variance showed that the highest root length/plant (37.77 cm) was recorded for *Acacia tortilis* which followed by *Acacia ehrenbergiana* (35.83 cm) with no significant differences between them, but it was significantly greater than *Salvadora persica, Acacia seyal* and *Ziziphus spina-christi* (21.55 cm) (Figure 3).

Results of this experiment show clear differences in roots length in the early stage of seedlings growth these difference decreases with time. According to Kozlowski (1946) deep root penetration in the soil is a major factor in drought resistance. Also Ahmed (1982) mentioned that root length is critically important at the early stages as it utilizes deep soil layers for moisture. In this respect, Bosshard (1966) mentioned that seedlings with poor roots are less drought- resistance than those with dense root systems.

4.6. Root fresh weight (mg) / plant:

At 90 days seedling age the highest root fresh weight (2720 mg) was recorded for *Acacia seyal* (Table 7), which was significantly greater than all other species *Acacia nubica, Acacia tortilis, Ziziphus aspina-christi, Acacia ehrenbergiana* and *Salvadora persica*. (300 mg)

At 145 days seedlings age the highest root fresh weight (2090 mg) was recorded for *Acacia seyal* which was significantly greater than all other species. This was followed by A*cacia nubica* (1.27mg), *Acacia tortilis, Acacia ehrenbergiana, Ziziphus spina-christi and Salvadora persica* (0.65mg) which were not significantly different between themselves.

At 190 days statistical analysis showed that there were highly significant differences; the highest mean fresh weight of roots/plant (2090 mg) was recorded for *Acacia seyal* which was significantly greater than all other species. This was followed by *Acacia nubica, Acacia ehrenbergiana, Acacia tortilis, Ziziphus aspina-christi and Salvadora persica.*

Results of this experiment show *Acacia seyal* and *Acacia nubica* as the highest root fresh weight among the tested species.

Table 6: Mean root length (cm)/ plant of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	27.16 bc	30.44 ab	26.83 b
Acacia nubica	23.22 cd	28.05 ab	30.33 ab
Acacia ehrenbergiana	30.61 ab	34.32 a	35.83 a
Ziziphus spina-christi	21.29 d	23.10 b	21.55 b
Acacia tortilis	32.33 a	29.38 ab	37.77 a
Salvadora persica	24.55 cd	28.44 ab	26.11 b
Over all mean	26.52	28.94	29.73

Figures followed by the same letter in the same column are not significantly different.

Table 7: Mean root fresh weight (mg) of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	2720 a	2090 a	2900 a
Acacia nubica	1230 b	1270 b	1680 b
Acacia ehrenbergiana	300 c	1120 b	1110 bc
Ziziphus spina-christi	890 bc	650 b	770 c
Acacia tortilis	90 b	1150 b	770 c
Salvadora persica	34 c	650 b	590 c
Over all mean	109	1060	1300

Figures followed by the same letter in the same column are not significantly different.

4.7. Root dry weight (mg) / plant:-

At 90 days seedlings age the highest root dry weight/plant (1040 mg) was recorded for *Acacia seya*l (Table 8), it was significantly greater than all other species, it followed by *Acacia tortilis, Acacia nubica, Acacia ehrenbergiana, Ziziphus spina-christi* and *Salvadora persica.* On the other hand *Acacia tortilis* was not significantly different from *Acacia nubica*, *Acacia ehrenbergiana* and *Ziziphus spina-christi*, but was significantly different from *Salvadora persica*. The other remaining species (*Acacia nubica*, *Acacia ehrenbergiana*, *Ziziphus spina-christi* and *Salvadora persica)* were not significantly different.

At 145 days seedlings age the highest root dry weight/plant (880 mg) was recorded for *Acacia seyal* which was significantly greater than all other species followed by *Acacia nubica, Acacia tortilis, Acacia ehrenbergiana, Ziziphus spina-christi* and *Salvadora persica* (200 mg).

At 190 days seedling age analysis of variance showed the highest root dry weight/plant (1130 mg) recorded for *Acacia seyal* which was significantly greater than all other species. This was followed by *Acacia nubica, Acacia ehrenbergiana, Acacia tortilis, Ziziphus spina-christi* and *Salvadora persica* (150 mg).

Results of this parameter exhibit *Acacia seyal, Acacia nubica and Acacia tortilis* as the species developing the biggest root systems among the tested species - a character of significance in drought tolerance.

4.8. Root collar diameter (mm) /plant:

There were no significant differences among the evaluated six species at 90 days seedlings age (Table 9), the overall mean collar diameter was 3.73mm.

At 145 seedlings age, *Acacia seyal (*4.83mm) gave the highest root collar diameter followed by *Acacia nubica , Ziziphus spina-chrisiti*, which were significantly greater than the other species *Acacia ehrenbergiana* (3.66mm), *Acacia tortilis* (3.38mm) and *Salvadora persica* (3.21mm) which were not significantly different between themselves.

At 190 days seedlings age the highest collar diameter/ plant (5.1 mm) was recorded for *Acacia seyal*; this was not significantly different from *Acacia nubica*, *Ziziphus spina-chrisiti* and *Acacia ehrenbergiana* but it was significantly different from *Acacia tortilis* (3.77mm) and *Salvadora persica* (3.33mm). The variations are shown in (Figure 4).

The results indicate that root collar diameter at early seedlings development dose not differ from one species to the other. At the later stages Acacia *seyal, Acacia nubica and Ziziphus spina-christi* developed greatest root collar diameter. In this respect Rahimatalla 2006 stated that *Acacia seyal variety seyal* develop a root collar diameter growth of 1cm per year under field conditions at Elrawashda forest reserve.

Table 8: Mean root dry weight (mg) of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	1040 a	880 a	1130 a
Acacia nubica	420 bc	540 b	650 b
Acacia ehrenbergiana	300 bc	470 bc	390 b c d
Ziziphus spina-christi	220 bc	320 bc	320 c d
Acacia tortilis	430 b	480 bc	150 d
Salvadora persica	170 c	200 c	590 b c
Over all mean	430	480	530

Figures followed by the same letter in the same column are not significantly different.

Table 9: Mean root collar diameter (mm) of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	4.44 a	4.83 a	5.10 a
Acacia nubica	3.88 ab	4.49 a	4.94 ab
Acacia ehrenbergiana	3.22 b	3.66 b	3.94 abc
Ziziphus spina-christi	3.88 ab	4.49 a	4.82 ab
Acacia tortilis	3.33 b	3.38 b	3.77 bc
Salvadora persica	3.66 ab	3.21 b	3.33 c
Over all mean	3.73	4.01	4.31

Figures followed by the same letter in the same column are not significantly different.

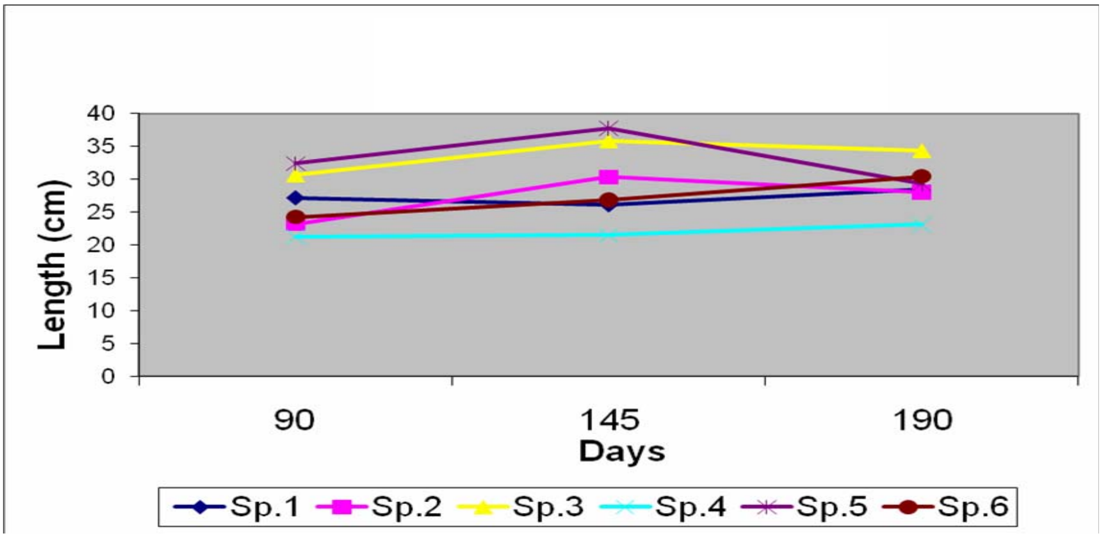

Figure 3: Root length (cm) of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina,Sp 4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

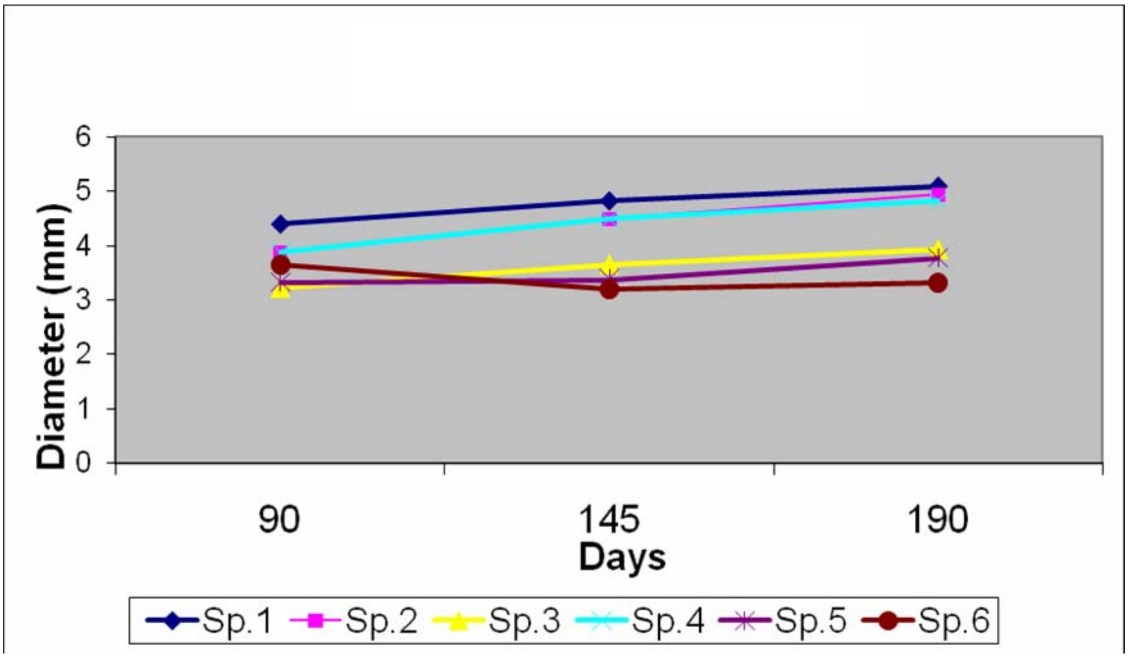

Figure 4: (mm) Root colar Diameter of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina, Sp4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

4.9. Number of leaves /plant:-

At 90 days seedlings age (Table 10) the highest number of leaves (24) was recorded for *Ziziphus spina-christi* which was followed by *Acacia ehrenbergiana.*These were significantly greater than *Acacia tortilis, Acacia nubica, Salvadora persica* and *Acacia seyal*.

There were no significant differences at 145 days seedlings age (table 9) the overall mean recorded for number of leaves/ plant was 19.84 leaves

At 190 days statistical analysis showed the highest number of leaves/ plant (38.88 leaves) recorded for *Ziziphus spina-christi* which was significantly greater than all other species *Acacia ehrenbergiana, Salvadora persica, Acacia tortilis, Acacia seyal,* and *Acacia nubica*(15.44).

The highest number of leaves in this experiment was recorded clearly for Zizphus spina- Christi, the matter which increases photothensis process of this species. Similarly Ahmed (2007) stated that *Ziziphus spina- christi* was a suitable species for arid land plantation due to its resistance for water stress. This property aim at fodder and timber production.

4.10. Number of pinnae pairs/plant:

The highest pinnae pair’s number (64.33 pairs) was recorded for *Acacia seyal* (Table 11), it followed by *Acacia tortilis, Acacia nubica, Acacia ehrenbergiana.*

At 145 days seedling age the highest pinnae pairs number (44.88 pairs) was recorded for *Acacia ehrenbergiana* followed by *Acacia tortilis, Acacia nubica and Acacia seyal* .

The highest mean number of pinnae pairs (54.33 pairs) at 190 days seedling age was recorded for *Acacia seyal* followed by *Acacia tortilis, Acacia nubica and Acacia ehrenbergiana* .

Table 10: Mean number of leaves/plant of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	13.66 c	15.44 bc	16.10 c
Acacia nubica	15.33 bc	12.33 c	15.44 c
Acacia ehrenbergiana	20.33 ab	22.00 abc	25.21 b
Ziziphus spina-christi	24.00 a	26.00a	38.88 a
Acacia tortilis	18.38 bc	19.44 abc	19.10 bc
Salvadora persica	15.33 bc	23.88 a	23.99 bc
Over all mean	17.83	19.84	23.12

Figures followed by the same letter in the same column are not significantly different.

Table 11: Mean number of pinnae pairs/plant of six arid land tree species:

Days / Species	90	145	190
Acacia seyal	64.33 a	30.44 a	54.33 a
Acacia nubica	44.67 a	39.89 a	47.99 a
Acacia ehrenbergiana	44.00 a	44.88 a	46.77 a
Ziziphus spina-christi	00.00 b	00.00 b	00.00 b
Acacia tortilis	54.67 a	44.55 a	49.88 a
Salvadora persica	00.00 b	00.00 b	00.00 b
Over all mean	51.91	39.94	49.74

Figures followed by the same letter in the same column are not significantly different.

4.11 germination period:

Table 11 gives the maximum period of germinastion for *Salvadora persica* (8.79 days) followed by *Ziziphus spina-christi, Acacia nubica, Acacia ehrenbergiana*, this is significantly greater than the period necessary for *Acacia tortilis* And *Acacia seyal. Acacia nubica* was not significantly different from *Acacia tortilis* And *Acacia seyal* . The germination period recorded for *Acacia tortilis* and *Acacia seyal* was (5.3 day) and (2.76 day) respectively (Figure 5).

4.12. Root/shoot ratio:

(Table 13) showed the highest root/shoot ratio was recorded for *Acacia seyal* (1.24) which was significantly greater from all the other remaining species (*Ziziphus spina-christi Acacia nubica, Salvadora persica , Acacia ehrenbergiana and Acacia tortilis (0.61)*

As a result *Acacia seyal* is considered as the most suitable species for plantation in arid and semi-arid lands with low water supply and relative humidity. Ahmed (1982) reported that there was increase in root growth relative to shoot growth in arid conditions (Figure 6).

Table 12. Mean germination period of six arid land tree species:

Species	Mean
Acacia seyal	2.76 b
Acacia nubica	5.76 ab
Acacia tortilis	5.13 b
Ziziphus spina-christi	8.48 a
Salvadora persica	8.79 a
Acacia ehrenbergiana	5.67 ab
Over all mean	6.09

Figures followed by the same letter in the same column are not significantly different.

Table 13 Mean root/shoot ratio of six arid land tree species:

Species	Mean
Acacia seyal	1.24 a
Acacia nubica	0.67 b
Acacia tortilis	0.61 b
Ziziphus spina-christi	0.83 b
Salvadora persica	0.61 b
Acacia ehrenbergiana	0.64 b
Over all mean	0.77

Figures followed by the same letter in the same column are not significantly different.

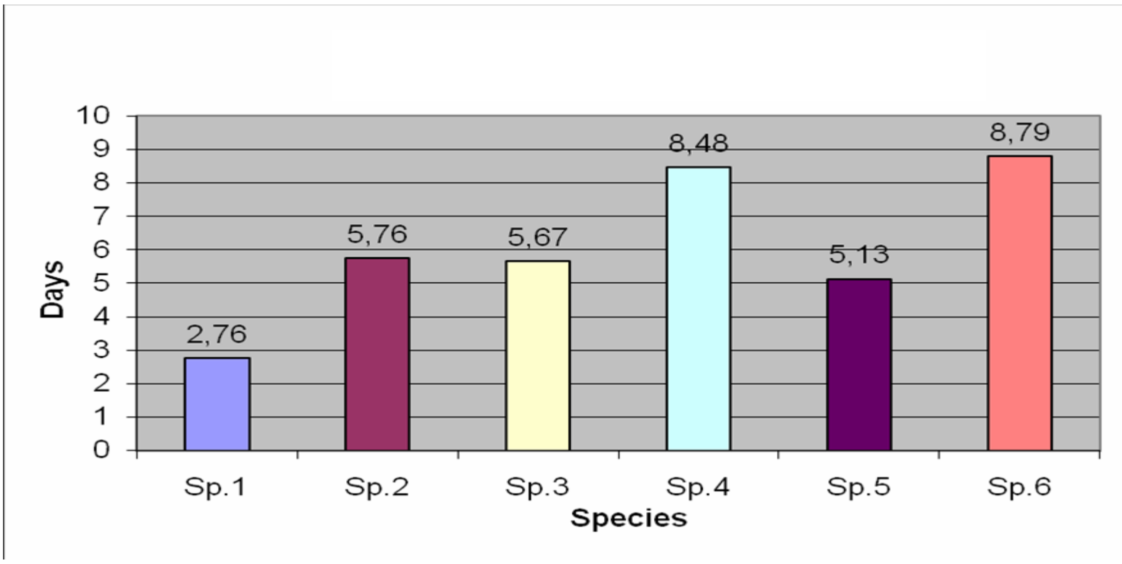

Figure 5: Mean days of germination of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina,Sp4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

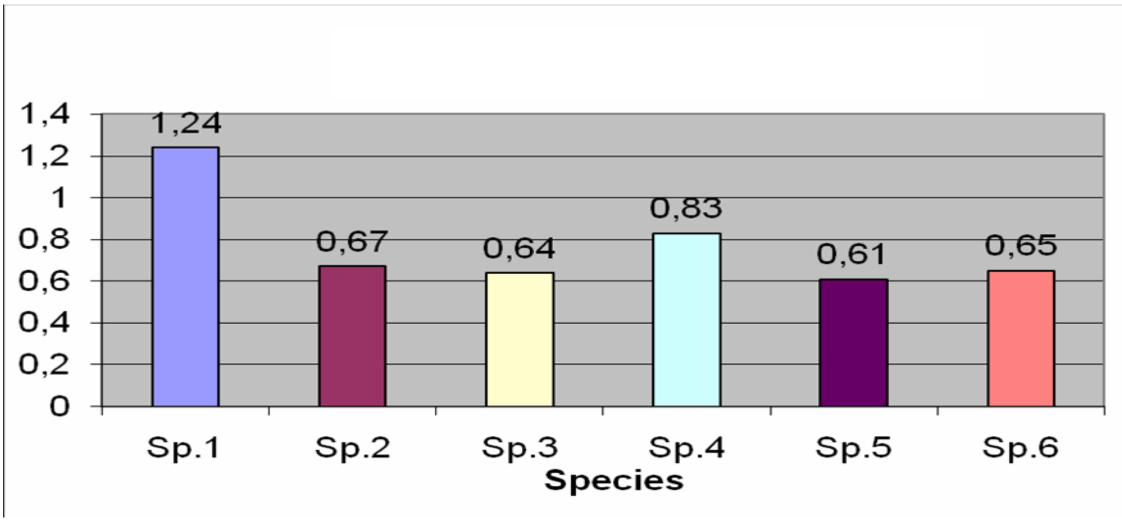

Figure 6: Root/ Shoot ratio of 6 arid land tree species

Sp1=Acacia seyal, Sp2= Acacia nubica, Sp3 =Acaciaehrenbergaina,Sp4 =Ziziphus spinachrsiti, Sp5= Acacia tortilis,Sp6= Salvadora persica.

Chapter five

Conclusion and Recommendations

Results of nursery tests revealed differences in seedlings growth performance between the different tested species *Acacia tortilis and ziziphus spina-christi* showed the highest survival percent.

The highest shoot length was attained by Acacia *seyal, Acacia tortilis* and *Acacia ehrenbergiana*. The longest roots were attained by *Acacia ehrenbergiana Acacia seyal, Acacia tortilis.* This is significant in arid lands since the long seedling roots can tap moisture from deep soil layer. On the basis of height, root length and survival percentage, *Acacia seyal, Acacia tortilis and Acacia ehrenbergiana* are most suitable for arid land conditions. The other species *Acacia nubica, Ziziphus spinachristi and Salvadora persica* come next.

Based on root length ,It is recommended that the following order be considered in selecting the species for a fforestation /reforestation programmes:

1) *Acacia ehrenbergiana*
2) *. Acacia tortilis*
3) *Acacia seyal.*
4) *Acacia nubica.*
5) *Salvadora persica*
6) *Ziziphus spina Christi.*
7) .

Acacia nubica being unpalatable for animals and unsuitable as fuel wood, may be used in stabilizing sand dunes and controlling sand movement.

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Appendices :

Appendix1. ANOVA: Mean squares from analysis of variance of the survival percent. Data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	156.9 **	227.52 **	209.52 ^{ns}
Error	12	11.5	15.11	71.27
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level.

Appendix 2. ANOVA table: Mean squares from analysis of variance of the shoot length data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	134.77 **	195.03 **	197.58 **
Error	12	15.88	20.11	27.23
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 3. ANOVA table: Mean squares from analysis of variance of the shoot fresh weight data of six tree species:

Source	**d. f**	**Mean squares**		
		90 days	145 days	190 days
Treatment	5	1.78 ^{ns}	0.26 ^{ns}	0.72 ^{ns}
Error	12	0.64	0.18	029
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 4. ANOVA table: Mean squares **from analysis of variance of the shoot dry data of six tree species:**

Source	**d. f**	**Mean squares**		
		90 days	145 days	190 days
Treatment	5	0.35 *	0.16 *	0.35 *
Error	12	0.08	0.04	0.08
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 5. ANOVA table: Mean squares from analysis of variance of the root length data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	55.76 **	114.4 *	39.89^{ns}
Error	12	6.7	25.12	23.48
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 6. ANOVA table: Mean squares from analysis of variance of the root fresh weight data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	2.34 **	.84 *	2.28 **
Error	12	0.15	.17	.14
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 7. ANOVA table: Mean squares from analysis of variance of the root Dry weight data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	.30 **	.16**	.35 **
Error	12	.01	.02	.03
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 8. ANOVA table: Mean squares from analysis of variance of the root collar diameter data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	0.58 ^{ns}	1.37 **	1.60 *
Error	12	0.32	0.14	0.46
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%lev

Appendix 9. ANOVA table: Mean squares from analysis of variance of number of leaves data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	44.63 **	80.90 ns	226.81 **
Error	12	8.61	29.70	23.89
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 10. ANOVA table: Mean squares from analysis of variance of the pinnae pairs number data of six tree species:

Source	d. f	Mean squares		
		90 days	145 days	190 days
Treatment	5	2322.45 **	1358.01 **	1999 **
Error	12	178.5	77.74	59.56
Total	17			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendi 11-ANOVA table (Mean days of germination)

Source	d.f	Ss	Ms	F value	F table
Treatment	5	75.9	15.18	4.86*	5% 3.11
Error	12	37.48	3.12		1% 5.06
Total	17	113.38			

Ns= non significant. *= significant at 5% level. **=significant at 1%level

Appendix 12. ANOVA table (Root/shoot ratio)

Source	d.f	Ss	Ms	F value	F table
Treatment	5	0.87	0.17	3.74*	5% 3.11
Error	12	0.56	0.04		1% 5.06
Total	17	1.44			

Ns= non significant. *= significant at 5% level. **=significant at 1%level